ARIZONA GAME AND FISH DEPARTMENT
HERITAGE DATA MANAGEMENT SYSTEM

Animal Abstract **Element Code:** AFCHA02100
Data Sensitivity: No

CLASSIFICATION, NOMENCLATURE, DESCRIPTION, RANGE

NAME: *Oncorhynchus gilae*
COMMON NAME: Gila Trout
SYNONYMS: *Salmo irrideus, Salmo gilae, Oncorhynchus gilae gilae*
FAMILY: Salmonidae

AUTHOR, PLACE OF PUBLICATION: *Salmo irrideus* Gibbons; Snyder 1915: (misidentification). *Salmo gilae* Miller 1950a: Occasional papers of the Museum of Zoology, University of Michigan.

TYPE LOCALITY: Main Diamond Creek, 53 KM ESE Beaverhead. T11S, R10W, Gila National Forest, Sierra Co., New Mexico; Gila National Forest, New Mexico.

TYPE SPECIMEN: The holotype, a mature male 204.0 mm (8.0 in.) in standard length, University of Michigan Museum of Zoology No. 137088, was secured by R.R. Miller from brood stock at the Glenwood Fish Hatchery, Glenwood, Catron County, New Mexico, on July 17, 1939. The stock reared at this hatchery came from Diamond Creek, a tributary of Gila River, approximately 33 miles east-southeast of Beaverhead, Sierra County, New Mexico. Twelve paratypes, U.M.M.Z. NO. 137089, 110.0 to 225.0 mm (4.3 to 8.9 in.) long, were obtained with the holotype. Sixty-two paratypes, 53.0 to 128.0 mm (2.1 to 5.0 in.) long, U.M.M.Z. No. 137090, were seined from Diamond Creek on July 18, 1939, by R.R. Miller and J. Davis.

TAXONOMIC UNIQUENESS: Related to other salmonids in genus *Oncorhynchus* in North America. Closely related to *Oncorhynchus apache* in Arizona. Behnke (1992) recognizes the two native Arizona trout as the subspecies *O. gilae gilae* and *O. gilae apache*.

DESCRIPTION: "Coloration: Head yellow with black spots; "cutthroat mark" yellowish; opercles dark copper; back and side above lateral line with a golden iridescence, sometimes washed with metallic blue, scattered with numerous dark spots (maximum, 30 per cm^2), spots larger dorsally, diminishing in size toward lateral line; a pinkish lateral band present; lower sides deep yellow; abdomen grayish white to pinkish orange. Fins: Dorsal yellow, first three or four rays yellowish orange to white, round or oval spots fine and dense; adipose deep yellow marked with large spots; caudal yellow, spotting dense; anal yellow with first five or six rays tipped with white, lower rays becoming reddish; pectorals and pelvics yellowish orange edged with white. Parr marks of young retained throughout life, becoming fainter with age" (Sublette et al. 1990).

"Head: Conical; SL/HL = 3.4-4.1; SL/HW = 6.5-6.7. Maxillary extending beyond eye. Basibranchial teeth usually absent (Behnke and Zarn 1976) although occasionally present in the Spruce and Dry Creek populations. Branchiostegal rays 10 (9-11). Gill rakers 19 (18-20)" (Sublette et al. 1990).

"Body: Average total length about 300.0 mm (11.8 in.); maximum total length approximately 550.0 mm (21.7 in.). SL/BD = 3.6-3.9. Lateral series with 130-165 scales. Scales above lateral line 24-38; below lateral line 23-27. Pyloric caeca 25-46 (Behnke and Zarn 1976). Vertebrae 59-63 (Minckley 1973; Behnke and Zarn 1976)" (Sublette et al. 1990).

"Fins: Dorsal triangular, origin anterior to that of pelvics. Adipose present dorsally, length about 11.6 per cent standard length. Caudal shallowly forked, lobes rounded. Anal triangular. Pectorals bluntly pointed. Pelvics short, about 14.0 per cent of standard length. Rays: Dorsal 9-12; pectorals 14 (13-15); pelvics 10 (9-10); anal 10 (9-11); caudal 18-19" (Sublette et al. 1990).

AIDS TO IDENTIFICATION: "The absence of both reddish markings on the inner border of the mandible (cutthroat markings) and large black spots (as large as the pupil of the eye) will distinguish *O. gilae* from *O. clarki*. The absence of reddish spots laterally will distinguish *O. gilae* from *Salmo trutta* and *Salvelinus fontinalis*. The golden yellow color dorsolaterally, and the presence of parr marks noticeable on fish up to 25.0 cm (9.8 in.) TL will distinguish *O. gilae* from *Oncorhynchus mykiss* (Walbaum). *Oncorhynchus gilae* superficially resembles *Oncorhynchus apache* which is known only from Arizona, although LaBounty and Minckley (1972) speculate that this species may have occurred in New Mexico in earlier times. However, *O. apache* has a spot behind the eye, on the head, and large spots on the body whereas *O. gilae* lacks the postorbital spot and is characterized by numerous small dark spots on the upper half of the body; spotting becomes more abundant on larger (>20.0 cm (7.9 in.) TL) adults" (Sublette et al. 1990).

ILLUSTRATIONS: Color drawing (Behnke 1992)
B&W drawing (Behnke (1992:213)
B&W photo (Minckley 1973:60)
Color drawing (Page and Burr 1991)
Color photo (Rinne and Minckley 1991:9)
Color drawing (Sublette et al. 1990)

TOTAL RANGE: "New Mexico: The Gila trout apparently occurred throughout the upper Gila drainage in New Mexico and Verde and Agua Fria drainage in Arizona. Its purported historical occurrence in Eagle Creek, Arizona, and the unique characteristics of individuals taken from Spruce Creek, suggest that it may also have been indigenous to the San Francisco drainage. Behnke and Zarn (1976) also cite the occurrence of trout similar to *O. gilae* from the Rio Yaqui of Mexico, a basin contiguous with the Gila River system. Gila trout have persisted in five streams within the Gila National Forest, New Mexico, including: Iron, McKenna, and Spruce creeks in the Gila Wilderness Area, along with Main and South Diamond creeks in the Aldo Leopold Wilderness Area. The populations in these five streams are genetically distinct (Loudenslager et al. 1986). There is recent speculation that the trout in upper White Creek may be pure Gila trout (P. Turner, pers. comm.). Confirmation of this awaits electrophoretic analysis. As a result of transplants, six additional populations of Gila trout exist in the Gila National Forest including populations in Sheep Corral (Canyon) Creek, a tributary of Sapillo Creek; McKnight Creek, a tributary of the Mimbres River; Little Creek, a tributary of the West Fork of the Gila River; Big Dry Creek (upstream of Golden Link Cabin) in the San Francisco River drainage; and Trail Canyon and Woodrow Canyon creeks along with the East Fork of Mogollon Creek, all tributaries of Mogollon Creek. The transplanted populations in Sheep Corral (Canyon) and McKnight come from Main Diamond Creek, while the populations in Little Creek is from McKenna Creek. The populations in the Mogollon Creek drainage are from South Diamond Creek. McKnight Creek is east of the Continental Divide and, therefore,

outside the historical distribution of the Gila trout. Hybridized populations (with *O. mykiss*) occur on the Gila National Forest in Black Canyon, Langstroth, Lipsey, upper Mogollon, White and Sycamore Canyon creeks (David 1976). Standing crops of Gila trout in the five original headwater streams range from 25.7 kg/ha to 200.3 kg/ha, thus equaling or exceeding those for other salmonids from comparable sized streams (Turner 1986)" (Sublette et al. 1990).

RANGE WITHIN ARIZONA: *Oncorhynchus gilae* found historically in the Verde and Agua Fria drainages in Arizona. Gila trout from Main Diamond Creek, Gila National Forest, New Mexico, were introduced into a tributary of the Verde River, Gap Creek, Prescott National Forest, Arizona, in 1974. Fisheries surveys in 1993 revealed no Gila trout and they were considered extirpated from Arizona. Historically, Gila trout may have occupied tributaries of the San Francisco River drainage, particularly Eagle Creek (Arizona) and Spruce Creek (New Mexico) (Minckley 1973, Mulch and Gamble 1956). Possible tributaries of the Verde River drainage, Arizona, Oak Creek and West Clear Creek may have had populations of Gila trout (Miller 1972). Sycamore Creek, a tributary of the Aqua Fria River, Arizona, historically may have had Gila trout (Behnke and Zarn 1976). Introduced into Dude Creek in September 1999. This population is in jeopardy stemming from problems resulting from the Dude Creek Fire.

SPECIES BIOLOGY AND POPULATION TRENDS

BIOLOGY: Spawns in late spring and summer. Hybridizes with non-native salmonids. Attains 7.6-10 cm (3-4 in) in the first year of life with maximum size being about 28-33 cm (11-13 in).

REPRODUCTION: "Spawning appears to occur during spring and summer in New Mexico. In McKnight Creek, where the population density is relatively low, female Gila trout mature at age III at a minimum size of 172.0 mm (6.8 in.) TL. In the more highly populated Main Diamond Creek, females reach maturity at age IV or V at a minimum size 133.0 mm (5.2 in.) TL (Nankervis 1988). Males tend to mature one to two years earlier than females in any given stream (P. Turner, pers. comm.). Rinne (1980) reported spawning from April through June when water temperatures were 8NC or greater; incubation required 8-10 weeks with the larvae emerging from the redds at 15.0-20.0 mm (0.59-0.79 in.) total length. Redd construction and spawning occurs as early as March in lower elevation streams and incubation and emergence probably can occur in less than eight weeks in warmer water temperatures (P. Turner, pers. comm.). Redds are usually constructed in water 7.6-15.2 cm (3-6 in) deep, with substrate 3.8 cm (1.5 in) or finer and range 0.8-1.4 m (2.5-4.5 ft) in diameter. Fecundity for Gila trout is related to size, age, and rate of growth (Nankervis 1988). According to Regan (1966), the number of eggs produced from females held in hatcheries averaged about 150. Nankervis (1988) reported the mean fecundity per female to be 143 and 335 eggs in Main Diamond and McKnight Creeks respectively. Maximum fecundity observed was 686 eggs. Mean ova diameter ranges from 2.72-4.00 mm (0.11-0.16 in.)" (Sublette et al. 1990).

"Sexual Differences: Breeding males with the pinkish lateral band intensified and the abdomen streaked with yellow or orange" (Sublette et al. 1990).

FOOD HABITS: An opportunistic feeder utilizing aquatic invertebrates, and small fishes, although it feeds primarily on adult and nymph stages of aquatic insects; trichopterans, ephemeropterans, chironomids, coleopterans and terrestrial insects. Gila trout generally feed from 0900 - 1300 (Van Eimeren 1988).

HABITAT: Gila trout are found in small mountain headwater streams, which are generally narrow and shallow, and rarely exceed 21°C (70°F). Siltation is usually low and cobble is the predominate substrate. During drought years they tend to be confined to pools with sufficient depth and cover. Gila trout use cover extensively (stream improvement structures, branches, logs and undercut banks). Tolerances to water chemical parameters (pH, conductivity dissolved oxygen, temperature, etc) are similar to other salmonids. Critical thermal maxima ranges 25.57-28.25°C.

ELEVATION: 1,660 - 2,810 m (5,446 - 9,220 ft.) in New Mexico (Gila National Forest).

PLANT COMMUNITY: Streams containing populations of Gila trout encompass two riparian vegetative communities (Brown 1982). The arctic-boreal riparian community occurs within subalpine forest (about 2,450-3,500 m elevation) and extends to lower elevations in cool microclimates. Shrub willows (e.g., *Salix monticola, S. scouleriana, S. bebbiana, S. irrorata*) commonly form thickets along streams. Other deciduous shrubs such as red elderberry (*Sambucus racemosa*), goose-berry currant (*Ribes* spp.), raspberry (*Rubus* spp.), and thin-leaf alder (*Alnus tenuifolia*) are also common. Tree species of the subalpine conifer forest such as Englemann spruce (*Picea englemannii*), blue spruce (*Picea pungens*), subalpine fir (*Abies lasiocarpa*), and aspen (*P. tremuloides*) are often present. The cold-temperate riparian community (about 1,700-2,300 m elevation) is the predominate type along streams currently occupied by Gila trout. Major components of this community are narrowleaf cottonwood (*P. angustifolia),* box elder (*Acer negundo*), alder (*A. oblongifolia*), and willows. Montane woodland and conifer forest species such as white fir (*A. concolor*), aspen, ponderosa pine (*Pinus ponderosa*), Gambel oak (*Quercus gambelii*), New Mexico locust (*Robinia neomexicana*), and smooth sumac (*Rhus glabra*) often occur. Shrub growth of willows and other species such as red-osier dogwood (*Cornus stolonifera*) and thin-leaf alder is frequently a dominant aspect.

POPULATION TRENDS: Historically and currently Gila trout populations are subjected to floods, fires, low flows (drought years) and grazing which can severely limit population size and density of this species (McHenry 1986, Mello and Turner 1980, Regan 1964, and Turner 1989).

Status of populations in New Mexico and Arizona:

Main Diamond Creek, N.M. Stream improvement structures were placed in this stream during the 1930's. Populations of Gila trout were stable until the Divide fire in 1989. 566 Gila trout were removed to Mescalero National Fish Hatchery during the fire. Hail and rainstorms occurred after the fire and total suspended solids in the stream on July 20, 1989 was 181, 452 mg/l (P.R. Turner 1991). Trout habitat was eliminated and no Gila trout were found during fisheries surveys in October 1989 and May 1990 (D.L. Propst 1991).
McKnight Creek, N.M. Flooding in 1988 resulted in a 90% loss of Gila trout (Turner 1989). In October 1989, 200 Gila trout from Main Diamond Creek were stocked in this stream. Stream improvement structures and willow plantings were installed in 1989-90.
Sheep Corral Canyon Creek N.M. In 1972, 89 Gila trout from Main Diamond Creek were transplanted into this stream to establish a new population (Turner 1989).
South Diamond Creek, N.M. Dry streambeds and effects of the Divide Fire have reduced Gila trout populations in certain reaches of this stream. A small population of Gila trout in the Burnt Canyon reach survived the fires and were found in May, 1990 (D.L. Propst 1991).

Trail Canyon Creek, N.M. Treated with antimycin A in October, 1986, and July, 1987, to remove non-native trout. 305 Gila trout from South Diamond Creek were stocked into this stream in September, 1987, and October, 1988. Reproduction was confirmed in 1989 (Propst et al. 1992).

Upper Mogollon Creek, N.M. Treated with antimycin A in July, 1987, and July, 1988, and April, 1989. 100 fingerling Gila trout and 93 adult Gila trout from Trial Canyon were stocked in this stream.

McKenna Creek, N.M. Gila trout population has hybridized with rainbow trout since 1974 (B. Riddle 1991).

Little Creek, N.M. Concrete barrier installed in 1982 and 9Km of stream treated with antimycin A. In December, 1982, 100 Gila trout from McKenna Creek were stocked into this stream. The population increased through 1988. Flooding in August 1988 diminished the Gila trout population.

Iron Creek, N.M. In 1981 a concrete barrier was installed. Treated with antimycin A in 1982-83, Gila trout survival was low. Additional stockings of Upper Iron Creek fish have showed an increase in the Gila trout population (Turner 1989).

Sacaton Creek, N.M. 40 Gila trout from Iron Creek were stocked into this stream in May, 1990. 60 additional fish were stocked in June, 1991.

Spruce and Big Dry Creeks, N.M. Spruce Creek population is alright and 97 fish from Spruce Creek were stocked into Big Dry Creek in October, 1985, following renovation with antimycin A in 1984. Fingerling Gila trout were found in 1990 (D.L. Propst 1991).

Gap Creek, Az In 1974, 65 Gila trout from Main Diamond Creek, were transplanted into this stream, a tributary of the Verde River in Prescott National Forest (Minckley and Brooks 1985 and Warnecke 1987). The population increased to 150 fish but has recently dwindled to just a few. Surveys in 1993 revealed no Gila trout (J. Warnecke pers. comm. 1994).

SPECIES PROTECTION AND CONSERVATION

ENDANGERED SPECIES ACT STATUS: LE (USDI, FWS 1973)
[LE USDI, FWS 1967]

STATE STATUS: WSC (AGFD, WSCA in prep)
[State Endangered AGFD, TNW 1988]

OTHER STATUS: Forest Service Sensitive (USDA, A/S National Forests 2000)
[Forest Service Sensitive, USDA, FS Region 3 1988]
State Endangered, Group II, State of New Mexico, 1975-01-24.

MANAGEMENT FACTORS: Gila trout populations in small headwater streams are susceptible to natural disasters; floods, fires, and drought. Habitat loss is a concern. Exotic fish species threaten the population with predation, competition, and hybridization (especially Rainbow and Brown Trout). **Management needs:** delineate specific conservation waters; maintain and/or enhance habitats; ameliorate effects of nonnative fishes from selected waters; reintroduce into selected habitats.

PROTECTIVE MEASURES TAKEN: Recovery plan completed, 1984. Selected streams have been renovated with antimycin A, fish barriers installed, habitat improvement structures installed, and reintroduced with pure strain Gila trout. Existing pure strain populations of Gila

trout in 10 streams of New Mexico are being maintained and improved. Fish culture of Gila trout is being investigated. Public education efforts are ongoing.

SUGGESTED PROJECTS: Additional streams need to be selected for introduction of Gila trout to maintain genetic purity and diversity of the species. Logging, mining, cattle and sheep grazing, and other developmental activities should be prohibited in drainages that could or already have Gila trout populations. Reserve streams for genetically pure Gila trout, with no stocking of non-native salmonids. A suitable fish hatchery should be selected for raising Gila trout for possible reintroductions into suitable habitats. Sport fishing should be prohibited until the species is downlisted to threatened status, at which time certain streams could be opened to fishing with special regulations (lure or fly only, barbless hooks, catch and release, etc.). Potential reintroduction sites for Gila trout should be investigated in the Verde River and Agua Fria River drainages. Possible streams to be investigated should include; Sycamore Creek, Oak Creek, Fossil Creek and East Verde River. If these sites are selected protection of these watersheds is crucial to the survival of Gila trout.

LAND MANAGEMENT/OWNERSHIP: USDA, Forest Service, Gila National Forest (New Mexico) and Tonto National Forest (Arizona).

SOURCES OF FURTHER INFORMATION

REFERENCES:

Arizona Game and Fish Department. 1988. Threatened Native Wildlife in Arizona. p. 27.

Arizona Game and Fish Department. In prep. Wildlife of special concern in Arizona. Arizona Game and Fish Department Publication. Phoenix, Arizona. 32 pp.

Arizona Game and Fish Department Native Fish Diversity Review. 1995. Tempe, Arizona.

Amaranthus, M., H. Jubas and D. Arthur. 1989. Stream shading, summer streamflow and maximum water temperature following intense wildlife in headwater streams. Proceedings of the Symposium on Fire and Watershed Management, October 26-28, 1988, Sacramento, California, USDA, Forest Service, General Technical Report PSW-109. pp. 75-78.

American Fisheries Society Western Division. 1980. Management and protection of western riparian stream ecosystems. pp. 24.

Armour, C.L. 1977. Effects of deteriorated range streams on trout. Bureau of Land Management. Idaho State Office, Boise. pp. 7.

Beamish, R.J. and R.R. Miller. 1977. Cytotaxonomic study of the Gila trout, *Salmo gilae*. Journal of the Fisheries Research Board of Canada 34:1041-1045.

Behnke, R.J. 1970. Rare and endangered species report: New information on Gila trout, *Salmo gilae*. Colorado Cooperative Fishery Unit, Colorado State University, Fort Collins. pp. 12.

Behnke, R.J. 1973. Gila trout, *Salmo gilae*. Endangered Species Report. U.S. Fish and Wildlife Service, Albuquerque, New Mexico. pp. 5.

Behnke, R.J. 1979. Monograph of the native trouts of the genus *Salmo* of western North America. Funded by USDA, Forest Service, U.S. Fish and Wildlife Service and U.S. Bureau of Land Management (inquiries: Regional Forester, 11177 West 8th Avenue, PO Box 25127, Lakewood, Colorado 80225). pp. 163.

Behnke, R.J. 1992. Native trout of western North America. American Fisheries Society Monograph 6. American Fisheries Society, Bethesda, Maryland. pp. 209-216.

Behnke, R.J. and M. Zarn. 1976. Biology and management of threatened and endangered western trouts. Technical Report RM-28, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado. pp. 45.

Berger, B.L. 1965. Antimycin (Fintrol) as a fish toxicant. Address for Delivery at Southern Division of the American Fisheries Society Meeting, Tulsa, Oklahoma. pp. 6.

Berger, B.L., R.E. Lennon and J.W. Hogan. 1969. Laboratory studies on antimycin A as a fish toxicant. Investigations in fish control, #26 US Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife, Washington, D.C. pp. 21.

Bickle, T.S. 1973. Gila trout management plan. USDA, Forest Service, Gila National Forest, Silver City, New Mexico. pp. 47.

Biota Information System of New Mexico, Web Site, http://www.fw.vt.edu.

Brown, D.E. 1982. Biotic communities of the American Southwest-United States and Mexico, Desert Plants. pp. 342.

Coman, C.H. 1981. Gila trout management and recovery activities with emphasis on Iron Creek recovery efforts. Mimeo. Gila National Forest, Silver City, New Mexico, pp. 34.

David, R.E. 1976. Taxonomic analysis of Gila and Gila x rainbow trout in southwestern New Mexico. Unpublished M.S. Thesis, New Mexico State University, Las Cruces. pp. 36.

Dennis, N. 1989. The effects of fire on watersheds: a summary. Sacramento, California. USDA, Forest Service General Technical Report PSW-109. pp. 92-94.

Gila Wilderness Web Site, http:/www.gilawilderness.com.

Gilderhus, P.A., B.L. Berger, and R.E. Lennon. 1969. Field trials of antimycin A as a fish toxicant. Investigations in fish control, #27. US Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife, Washington D.C. pp. 22.

Gold, J.R. 1977. Systematics of western North American trout, (*Salmo*), with notes on the redband trout of Sheephaven Creek, California. Canadian Journal of Zoology. 55(11):1858-1873.

Hanson, J.N. 1971. Investigations on Gila trout, *Salmo gilae* Miller, in southwestern New Mexico. Unpublished M.S. Thesis. New Mexico State University, Las Cruces,. pp. 44.

Herr, F., E. Greselin, and C. Chappel. 1967. Toxicology studies of antimycin, a fish eradicant. Transactions of the American Fisheries Society 96(3):320-326.

Jacobi, G.Z. 1988. Benthic macroinvertebrate assessment: benthic macroinvertebrate samples from the Mogollon River and tributaries, Gila National Forest, New Mexico. Unpublished report. New Mexico Highlands University, Las Vegas, New Mexico. pp. 5.

Kennedy, C. 1977. Wildlife conflicts in riparian management: Water. pp. 52-28. *in* Symposium on Importance, Preservation and Management of Riparian Habitat. U.S. Forest Service, General Technical Report RM-43.

LaBounty, J.F. and W.L. Minckley. 1972. Native fishes of the upper Gila River system, New Mexico, pp. 134-146. *in* Symposium on rare and endangered wildlife of the southwestern United States. New Mexico Department of Game and Fish, Sante Fe.

Lee, R.M. and J.N. Rinne. 1980. Critical thermal maxima of five trout species in the southwestern United States. Transactions of the American Fisheries Society 109:632-635.

Legendre, P., C.B. Schreck, and R.J. Behnke. 1972. Taximetric analysis of selected groups of western North American *Salmo* with respect to phylogenetic divergences. Systematic Zoology 21(3):292-307.

Loudenslager, E.J. and G.A.E. Gall. 1981. Cutthroat trout: A biochemicalgenetic assessment of their status and systematics. Unpublished draft report, Department of Animal Science, University of California, Davis. pp. 89.

Loudeslager, E.J., J.N. Rinne, G.A.E. Gall, and R.E. David. 1986. Biochemical genetic studies of native Arizona and New Mexico trout. The Southwestern Naturalist. 31(2):221-234.

Mangum, F.A. 1981. Aquatic ecosystem inventory - macroinvertebrate analysis, Gila National Forest. USDA, Forest Service Annual Progress Report, Forest Service Intermountain Region Aquatic Ecosystem Analysis Laboratory, Provo, Utah. pp. 3.

Mangum, F.A. 1984. Aquatic ecosystem inventory - macroinvertebrate analysis, Gila National Forest. USDA, Forest Service Annual Progress Report, Forest Service Intermountain Region Aquatic Ecosystem Analysis Laboratory, Provo, Utah. pp. 9.

Mangum, F.A. 1985. Aquatic ecosystem inventory - macroinvertebrate analysis, Gila National Forest. USDA, Forest Service Annual Progress Report, Forest Service Intermountain Region Aquatic Ecosystem Analysis Laboratory, Provo, Utah. pp. 18.

Marcuson, P.E. 1977. The effect of cattle grazing on brown trout in Rock Creek, Montana. Project No. F-20-R-21-11-a. Montana Department Fish and Game, Helena. pp. 26.

McHenry, M.L. 1986. A test of the habitat quality index in forested headwater streams of the Gila National Forest, New Mexico. Unpublished M.S. Thesis. New Mexico State University, Las Cruces. pp. 73.

Medina, A.L. and S.C. Martin. 1988. Stream channel and vegetation changes in sections of McKnight Creek, New Mexico. Great Basin Naturalist 48(3):373-381.

Mello, K., and P.R. Turner. 1980. Population status and distribution of Gila trout in New Mexico. Endangered Species Report No. 6, U.S. Fish and Wildlife Service, Albuquerque, New Mexico. pp. 53.

Miller, R.R. 1950. Notes on the cutthroat and rainbow trouts with the description of a new species from the Gila River, New Mexico. University of Michigan Press, Ann Arbor, Michigan. Occasional Papers of the Museum of Zoology 529:1-43.

Miller, R.R. 1961. Man and the changing fish fauna of the American Southwest. Papers of the Michigan Academy of Science, Arts and Letters 46:365-404.

Miller, R.R. 1972. Classification of the native trouts of Arizona with the description of a new species, *Salmo apache*. Copeia 3:401-422.

Minckley, W.L. 1973. Fishes of Arizona. Arizona Game and Fish Department, Phoenix. pp. 60-63.

Minckley, W.L. and J.E. Brooks. 1985. Transplantations of native Arizona fishes; records through 1988. Journal of Arizona Nevada Academy of Science 20(2):73-89.

Mulch, E.D. and W.C. Gamble. 1956. Game fishes of Arizona. Arizona Department of Game and Fish, Phoenix. pp. 19.

Murphy, D.D., K.E. Freas and S.B. Weiss. 1990. An environment-metapopulation approach to population viability analysis for a threatened invertebrate. Conservation Biology 4(1):41-51.

Nankervis, J.M. 1988. Age, growth and reproduction of Gila trout in a small headwater stream in the Gila National Forest. Unpublished. M.S. Thesis. New Mexico State University, Las Cruces. pp. 58.

Needham, P.R., and R. Gard. 1959. Rainbow trout in Mexico and California with notes on the cutthroat series. University of California Publications in Zoology 67(1):1-124.

Novak, M.A. 1988. Impacts of a fire-flood event on physical and biological characteristics of a small mountain stream. Unpublished M.S. Thesis. Montana State University, Bozeman. pp. 110.

Page, L.M. and B.M. Burr. 1991. A field guide to freshwater fishes: North America, north of Mexico. Houghton Mifflin Co., Boston. p. 54.

Pittenger, J.S. 1986. Invertebrate drift before and after trout removal from a southwestern stream. Unpublished M.S. Thesis, New Mexico State University, Las Cruces, New Mexico. pp. 73.

Platania, S.P. USGS Web Site, http://biology.usgs.gov.

Platts, W.S. 1990. Managing fisheries and wildlife on rangeland grazed by livestock. Prepared for Nevada Department of Wildlife. Don Chapman Consultants, Inc. Boise, Idaho.

Platts, W.S. 1991. Livestock grazing. *in* W.R. Meehan, editor. Influences of forest and rangeland management on salmonid fishes and their habitats. American Fisheries Society Special Publication 19.

Platts, W.S. and M.L. McHenry. 1988. Density and biomass of trout and char in western streams. USDA, Forest Service, General Technical Report INT-241, Intermountain Research Station, Odgen, Utah. pp. 17.

Propst, D.L. 1988. Investigations and recovery of Gila trout. Project No. E-7-2. New Mexico Department Game and Fish, Santa Fe. pp. 11.

Propst, D.L., J.A. Stefferud, and P.R. Turner. 1992. Conservation and status of Gila trout, *Oncorhynchus gilae* (Miller). The Southwestern Naturalist.

Quinn, J.F. and A. Hastings. 1987. Extinction in subdivided habitats. Conservation Biology 1:198-208.

Regan, D.M. 1964. Ecology of Gila trout, *Salmo gilae*, in Main Diamond Creek, New Mexico. Unpublished M.S. Thesis, Colorado State University, Fort Collins. pp. 57.

Rinne, J.N. 1978. Development of methods of population estimation and habitat evaluation for management of the Arizona and Gila trouts. *in* J. Moring, ed. Proceedings of the wild trout - catchable trout symposium. Oregon Department of Fish and Wildlife, Corvallis. pp. 113-125.

Rinne, J.N. 1980. Spawning habitat and behavior of Gila trout, a rare salmonid of the southwestern United States. Transactions of the American Fisheries Society 109:83-91.

Rinne, J.N. 191. Stream habitat improvement and native southwestern trouts. USDA, Forest Service Research Note RM-409, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado. pp. 4.

Rinne, J.N. and W.L. Minckley. 1991. Native fishes of arid lands: A dwindling resource of the desert southwest. USDA, Forest Service, General Technical Report RM-206, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado. pp. 7-10.

Rinne, J.N. and P.R. Turner. 1991. Reclamation and alteration as management techniques, and a review of methodology in stream renovation. *in* W.L. Minckley and J.E. Deacon, eds. Battle against extinction: native fish management in the American West. University of Arizona Press, Tucson. pp. 400-448.

Roby, K.B. 1989. Watershed response and recovery from the Will Fire: ten years of observation. Proceedings of the Symposium on Fire and Watershed Management, October 26-28, 1988, Sacramento, California. USDA, Forest Service, General Technical Report PSW-109. pp. 131-136.

Schreck, C.B. and R.J. Behnke. 1971. Trouts of the Upper Kern River Basin, California, with reference to systematic and evolution of western North American *Salmo*. Journal of the Fisheries Research Board of Canada 28:987-998.

Shaffer, M.L. 1981. Minimum viable population sizes for conservation. Bioscience 31:131-134.

Smith, G.R. and R.E. Stearly. 1989. The classification and scientific names of rainbow and cutthroat trouts. Fisheries 14(1):4-10.

Snyder, J.O. 1915. Notes on a collection of fishes made by Dr. Edgar A. Mearns from rivers tributary to the Gulf of California. Proc. U.S. National Museum 49:573-586.

Sublette, J.E., M.D. Hatch and M. Sublette. 1990. The fishes of New Mexico. University of New Mexico Press, Albuquerque. pp. 57-60.

Thurston, R.V., R.C. Russo, C.M. Fetterolf, Jr., T.A. Edssall and Y.M. Barber, Jr., eds. 1979. A review of the EPA redbook: quality criteria for water. Water Quality Section, American Fisheries Society, Bethesda, Maryland.

Turner, P.R. 1984. Gila trout activities during 1984 (Summary of fieldwork involving New Mexico State University). pp. 8.

Turner, P.R. 1986a. Restoration of the endangered Gila trout. Proceedings of the Annual Conference of the Western Association of Fish and Wildlife Agencies 66:122-133.

Turner, P.R. 1986b. Summary of McKnight Creek Gila trout population status. Unpublished Report. New Mexico State University, Las Cruces. pp. 21.
Turner, P.R. 1989. Annual and seasonal changes in populations of Gila trout in headwater streams. Final Report to the New Mexico Department of Game and Fish, Santa Fe. pp. 93.
Turner, P.R. and M.L. McHenry. 1985. Population ecology of the Gila trout with special emphasis on sport fishing potential. Unpublished final report to New Mexico Department of Game and Fish, Santa Fe. pp. 70.
USDA, Forest Service. 1979. Environmental assessment; Gila trout recovery projects on the Gila National Forest. USDA, Forest Service, Gila National Forest, Silver City, New Mexico. pp. 51.
USDA, Forest Service. 1986. Gila National Forest Plan. USDA, Forest Service, Southwestern Region, Albuquerque, New Mexico. pp. 324.
USDA, Forest Service. 1987. Rancher field day August 18, 1987. History. Gila National Forest, Silver City, New Mexico. p. 1.
USDA, Forest Service Region 3 1988. Regional Forester's Sensitive Species List.
USDA, Forest Service. 1990. Allotment management plan proposal for the Diamond Bar Allotment. Gila National Forest, Mimbres Ranger District, Mimbres, New Mexico. pp. 54.
USDA, Forest Service. 2000. Apache-Sitgreaves National Forests Sensitive Species List.
USDI, Fish and Wildlife Service. 1967. Native fish and wildlife; endangered species. Federal Register. 32:4001.
USDI, Fish and Wildlife Service. 1973. Endangered Species Act.
USDI, Fish and Wildlife Service. 1975. Endangered and threatened wildlife and plants; reclassification of the American alligator and other amendments. Federal Register 40:44415.
USDI, Fish and Wildlife Service. 1979. Recovery plan for Gila trout, *Salmo gilae* Miller 1950. Mimeo. U.S. Fish and wildlife Service, Albuquerque, New Mexico. pp. 45.
USDI, Fish and Wildlife Service. 1984. Gila trout recovery plan. U.S. Fish and Wildlife Service, Albuquerque, New Mexico. pp. 52.
USDI, Fish and Wildlife Service. 1987. Endangered and threatened wildlife and plants; proposed reclassification of the Gila trout (*Salmo gilae*) from endangered to threatened. Federal Register. 52:37424-37427.
USDI, Fish and Wildlife Service. 1988. Gila trout propagation - Mescalero National Fish Hatchery. FY-88 Regional Funds and Work Guidance, Task Number 22.370. Unpublished. U.S. Fish and Wildlife Service, Mescalero National Fish Hatchery, New Mexico. pp. 4.
USGS Web Site, http://biology.usgs.gov.
Van Eimeren, P.A. 1988. Comparative food habits of Gila trout and speckled dace in a southwestern headwater stream. Unpublished M.S. Thesis, New Mexico State University, Las Cruces. pp. 59.
Walker, C.R., R.E. Lennon, and B.L. Berger. 1964. Preliminary observations on the toxicity of antimycin A to fish and other aquatic animals. Investigations in Fish Control, Vol. 2. U.S. Bureau of Sport Fisheries and Wildlife.
Warnecke, J. 1987. Fisheries inventory of Gap Creek, Yavapai County, Arizona. Unpublished Report. Arizona Game and Fish Department, Phoenix. pp. 9.
Wilcove, D.S., C.H. McClellan and A.P. Dobson. 1986. Habitat fragmentation in the temperate zone. *in* M.E. Soule, ed. Conservation biology: the science of scarcity and diversity. Sinauer Associates, Sunderland, Massachusetts. pp. 237-256.

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ADDITIONAL INFORMATION:

The Gila Trout Recovery Team, a Multi-Agency task force, recommended that the USFWS downlist the species to threatened in 1987. However before the comment period was over, a flood eliminated more than 80% of the McNight Creek, NM population, a forest fire along with subsequent flooding eliminated the Main Diamond Creek population (the Type Locality) and drought and forest fire eliminated 90% of the South Diamond Creek population. The proposal to downlist this species was thus aborted. These events point out the fragility of small populations and dramatically demonstrates the potential for serious problems in recovery strategies.

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